Transformation for Environmental Schools: Opportunities and Challenges

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Article info

Abstract

This study analyzes the opportunities and challenges in establishing graduate-level environmental schools to address increasingly complex and severe environmental crises, particularly the impacts of global climate change, which has increased by 1.1°C since the pre-industrial era and is likely to reach 1.5°C by the 2030s without urgent action. The study reveals five key opportunities: responding to labor market demands, integrating interdisciplinary knowledge, leveraging digital technologies, fostering green innovations, and supporting sustainable development goals. Conversely, seven primary challenges are identified: designing curricula that encompass complex environmental issues, balancing theory and practice, adapting to rapid changes, managing resources, building cross-sector partnerships, cultivating diverse skill sets in students, and fostering environmental consciousness. The study emphasizes the importance of developing flexible curricula and integrating practical learning experiences.This study contributes significantly to the ongoing discourse on environmental education and provides insights for policymakers and educational institutions in developing effective environmental schools for the future. The findings underscore the potential of environmental schools to create positive societal and environmental impacts by developing human resources capable of navigating future social and environmental transitions.

Introduction

When discussing transitional eras, many may think of epoch changes at a particular point in time. However, this study focuses on the era of environmental change that is transitioning into a period of environmental crisis, particularly the crisis arising from global climate change. This is a global challenge that must be addressed by all countries.

According to the report by the Intergovernmental Panel on Climate Change (IPCC), the global average temperature has increased by 1.1°C since the pre-industrial era and is likely to reach 1.5°C by the 2030s if urgent action is not taken. The resulting impacts will lead to an increase in natural disasters, loss of critical ecosystems, and threats to human food and water security (IPCC, 2022). Furthermore, the United Nations Environment Programme (UNEP) predicts that without

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significant changes in policies and behaviors, the world will face increased deforestation, severe freshwater shortages, and an exponential increase in plastic waste in the oceans by 2050 (UNEP, 2023).

These environmental challenges have resulted in a significant increase in the demand for personnel with environmental expertise. The World Economic Forum (2023) states that environmental and sustainability-related professions will be among the fastest-growing fields in the next decade. It is projected that the demand for natural resource management specialists, environmental scientists, and clean energy experts will increase by more than 30% by 2030. Additionally, the International Labour Organization (ILO) estimates that the transition to a green economy will create over 24 million new jobs worldwide by 2030, particularly in renewable energy, environmentally friendly construction, and waste management sectors, which require personnel with specific environmental knowledge and skills (ILO, 2022).

The future labor market will see a significant increase in demand for environmental experts due to escalating environmental challenges. Studies indicate a growing need for workers in environmentally-friendly sectors such as renewable energy, energy-efficient building retrofits, and recycling industries (Bohnenberger, 2022). Moreover, environmental skills will be increasingly required across all professions, not just in environmental sectors. Environmental specialists will play crucial roles in shaping environmental policies, preparing environmental impact assessments, and providing environmental management consultancy to various organizations (Lobeyko et al., 2021). Consequently, environmental education is vital in preparing the workforce for future labor market needs. Educational institutions must develop curricula that align with these demands, emphasizing the integration of environmental education into various programs to enhance students' environmental knowledge, skills, and attitudes (Corpuz et al., 2022). This approach will help produce professionals capable of effectively addressing and managing future environmental challenges.

The development of environmental schools in higher education is therefore a crucial step in preparing and creating personnel with knowledge, skills, and positive attitudes towards the environment. Sebire & Isabeles-Flores (2023) emphasize that environmental education in higher education should prioritize the integration of cross-disciplinary knowledge, practical training, and the cultivation of systems thinking skills to equip graduates with the ability to address complex environmental challenges. Geng et al. (2023) advocate for a curriculum that combines foundational knowledge in environmental science, clean technology, and natural resource management with competencies in data analysis, geographic information systems (GIS), and science communication. Additionally, they stress the importance of promoting project-based learning and internships with environmental organizations, enabling students to gain real-world experience and establish professional networks.

This study seeks to analyze the opportunities and challenges associated with establishing environmental schools in higher education through document analysis. Its goal is to envision the future of environmental schools as institutions that foster learners' knowledge, skills, and positive attitudes toward environmental stewardship. The study's findings highlight key opportunities and challenges across various dimensions, providing valuable insights for the development of management models for environmental schools within higher education institutions.

Rapid environmental changes

The increase in global temperature is a key factor in current environmental changes. Monitoring the global temperature situation from 1850 to 2023 (as shown in Fig. 1) reveals that 2023 had the highest average global surface temperature in history. Over the past 47 years, the world's average temperature has been steadily increasing (National Oceanic and Atmospheric Administration [NOAA], 2024). This situation has widespread effects on ecosystems and worldwide populations (Morice et al., 2021), especially in the Arctic region where temperatures are rising twice as fast as the global average, resulting in a significant reduction in ice melting and posing a major problem for maintaining the world's balance in various aspects (Pagano & Williams, 2021).
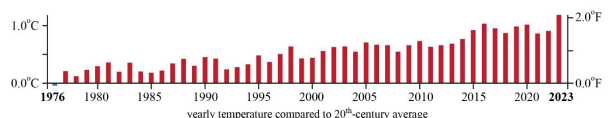

Fig. 1 Annual temperature compared to the 20th-century average
Source: NOAA (2024)

At the regional level, urban areas demonstrate a clear decline in environmental quality, particularly in air quality, with pollution driven by both the transportation and industrial sectors. Manisalidis et al. (2020) reported that air pollution in major cities of developing countries is responsible for approximately 9 million premature deaths annually worldwide. An assessment of vehicular air pollution in the Bangkok Metropolitan Region, Thailand, for the period 2021-2050, without additional control measures, predicts a continuous increase in pollutants across all types. This trend is attributed to the inadequacy of current measures in addressing the growing number of vehicles and rising travel demands (Kuson et al., 2023). Furthermore, urban expansion has severely contaminated surface and groundwater sources, posing long-term risks to human health and water security.

Another significant factor contributing to rapid environmental change is technological advancement, particularly digital transformation. Oo et al. (2023) highlighted that the proliferation of digital technology has substantially increased the carbon footprint, particularly through the use of electronic devices such as smartphones, tablets, and computers. For example, they estimated that watching one hr of Netflix streaming releases 36 g of carbon dioxide, and data transmission from such activities is projected to increase 14-fold between 2020 and 2030.

However, technological advancements do not solely have negative environmental impacts. Digital technologies also contribute to environmental monitoring, surveillance, and problem-solving. For instance, Internet of Things (IoT) systems are now used for continuous 24-h water quality monitoring (Chowdury et al., 2019), and video conferencing systems, such as those used in telemedicine, reduce the need for travel by patients and medical personnel, thereby lowering carbon dioxide emissions (Morcillo Serra et al., 2022).

The rapid environmental changes are largely driven by population growth and urban expansion. By 2030, it is estimated that up to 290,000 km^2 of habitat for living organisms will be lost due to urbanization (Simkin et al., 2022). A global population assessment predicts that by 2100, the world population will reach 10.3 billion, an increase of 2.2 billion from the present (United Nations, Department of Economic and Social Affairs, Population Division, 2022). This growth will significantly impact resource use and greenhouse gas emissions (Vollset et al., 2020). However, Wiedmann et al.

(2020) argue that excessive consumption in wealthy countries remains the primary driver of global environmental impacts.

Based on the above, the current environmental situation is rapidly evolving, with complex and interconnected challenges. The principal causes are population growth and unchecked consumption. Addressing these environmental issues requires interdisciplinary knowledge and expertise. Developing environmental schools with curricula that are responsive to both current and future global environmental needs is a key strategy for mitigating this crisis.
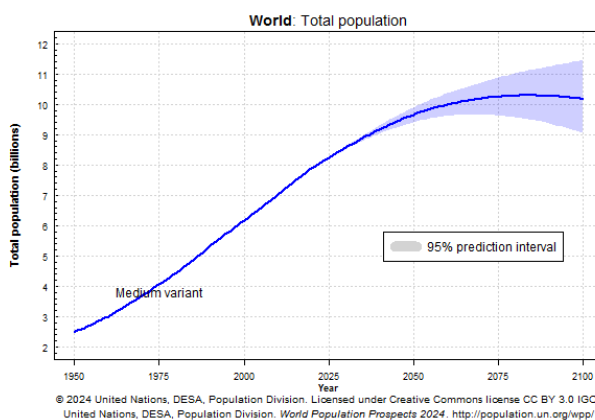

Fig. 2 World Population Projection to 2100
Source: United Nations, Department of Economic and Social Affairs, Population Division (2024)

Situation and direction of higher education institutions

Higher education institutions worldwide are facing rapid challenges and changes in various aspects, including technology, the economy, and society, all of which influence education management and human resource development. Analyzing the current situation and future trends in higher education is critical for understanding and shaping its direction. One of the primary drivers of change is digitalization, which has transformed teaching methods and administrative practices in higher education institutions, particularly during the COVID-19 pandemic when institutions rapidly shifted to online learning (König et al., 2020). As a result, developing the digital competencies of students and staff has become a key focus in higher education. Frameworks such as the Digital Competence Framework for Citizens (DigComp) in the European Union and the International Society for Technology in Education (ISTE) in the United States have been

employed to assess digital skills of personnel through self-assessment tools or tests based on these frameworks (Sillat et al., 2021).

Additionally, neoliberalism and globalization have had a profound impact on the direction of higher education, particularly in the commodification of education. This has pushed universities to align with the demands of the global labor market and economy (Marginson, 2022). For example, in Australia, policies like Job-Ready Graduates (JRG) have promoted curriculum shifts toward Science, Technology, Engineering, and Mathematics (STEM) fields while reducing support for the humanities and liberal arts (Davis, 2022).

However, the emphasis on market-driven education may compromise the social and cultural missions of higher education. Efforts are being made to balance economic responsiveness with social development, as seen in Australia's Universities Accord initiative, which aims to create a long-term vision for quality, accessibility, and affordability in higher education (Department of Education, 2023).

Curriculum development is another critical area of focus. Trends are moving toward greater flexibility, such as the adoption of micro-credential systems, which allow learners to accumulate credits toward higher qualifications (Department of Education, Skills and Employment, 2022). Professional development for educators is also essential. Tran et al. (2020) highlight that investing in faculty development enhances education quality and student achievement, making it vital for institutions to promote lifelong learning and skill development among staff to keep pace with technological and market demands.

Based on the analysis of these trends, the future development of higher education institutions can be summarized as follows:

1) Implementing learning management systems that leverage technology and innovation

2) Promoting professional development and lifelong learning for staff

3) Enhancing curricula and teaching processes to develop critical thinking and socio-emotional skills

4) Establishing support systems to meet diverse learner needs

5) Encouraging international collaboration to exchange knowledge and experiences in educational development.

In conclusion, ongoing educational research will help higher education institutions adapt to the challenges of the 21st century, considering the unique contexts and needs of each country and region.

Developing environmental curricula to support future environmental challenges

Environmental curricula aim to equip students with a comprehensive understanding of environmental processes and the ability to apply this knowledge in managing environmental issues. However, Marzuki and Ansar (2024) identify significant gaps in current environmental education that hinder its effectiveness in addressing contemporary challenges. They outline three primary challenges:

1. Lack of Comprehensive Integration: Current curricula often fail to deeply integrate environmental knowledge, particularly in areas like ecosystems, natural resource sustainability, and social responsibility toward the environment. This limits students' understanding of the complexity of environmental issues.

2. Inconsistent Curriculum Implementation: Variability in policies and priorities across institutions results in unequal access to environmental education, leading to disparities in student knowledge and skills.

3. Insufficient Resources and Educator Training: Many educators lack the training and resources needed to effectively deliver environmental education, which impacts the quality of learning experiences.

To develop environmental professionals capable of addressing current and future environmental challenges, curricula must evolve to align with changes in economic, social, and environmental dimensions. Based on analysis, eight key considerations for developing environmental curricula include:

1. Integrating sustainability and circular economy concepts

Currently, the global focus is on sustainability (SDGs) and circular economy (BCG) concepts. These two frameworks drive environmental initiatives across multiple dimensions and deeply explore the relationship between humans and nature. For instance, environmentally friendly business operations require personnel skilled in environmental practices and circular economy principles. The European Union has been actively applying these concepts in business and industry sectors (Bassi & Guidolin, 2021).

2. Developing essential skills for the environmental labor market

Moreno-Mondéjar et al. (2021) indicate that the

environmental labor market increasingly demands personnel with diverse and specialized skills, particularly in technology and innovation related to environmental problem-solving. Additionally, Unay-Gailhard and Bojnec (2019) emphasize that environmental personnel must possess analytical thinking skills. Therefore, current environmental curricula must focus on developing analytical and problem-solving skills, incorporating modern technology through active learning activities and research projects.

3. Addressing environmental challenges in the digital era

A major challenge across many professions is the rapid change in digital technology and its subsequent environmental impacts. These impacts represent new knowledge that environmental professionals and stakeholders must learn to address, such as digital pollution resulting from widespread digital technology use. Curricula must incorporate content on these impacts, including the use of renewable energy in digital device production and operation, and energy-efficient software and application design (Oo et al., 2023). Furthermore, curricula should emphasize developing skills in big data analytics and artificial intelligence for application in environmental problem-solving (World Economic Forum and Accenture, 2022).

4. Fostering industry and community collaboration

To ensure curricula meet current and future labor market demands, curriculum development and teaching processes must foster collaboration with industry and local communities. This includes promoting internships and joint projects with industry, allowing students to learn from real experiences and understand labor market needs. Additionally, inviting experts from the private sector as guest lecturers or to co-develop curricula ensures that educational content remains current and aligned with industry requirements. These actions also enhance the attractiveness of the curriculum and student enrollment (Khan & Muktar, 2020).

5. Promoting critical and problem-solving skills

Given the complexity of current environmental issues, future environmental professionals must possess analytical skills to effectively address problems arising. Sulich et al. (2021) suggest that new management and decision-making models are crucial for environmentally friendly strategies. Therefore, curricula should promote teaching methods that emphasize case study analysis, group discussions, and research projects aimed at solving real environmental problems to hone students' critical thinking and problem-solving skills.

6. Continuing curriculum improvement

To respond to rapid changes across various fields, Bohnenberger (2022) recommends using a modular teaching approach that is easily adaptable and updatable. Additionally, promoting lifelong learning through short courses or online training for working professionals ensures that environmental sector personnel can continuously develop their skills and knowledge to keep pace with changes.

7. Enhancing communication and cooperative skills

Essential skills for environmental professionals include communication and collaboration, as environmental work often involves multiple stakeholders. Environmental curricula must emphasize the importance of effectively communicating environmental issues by incorporating learning activities that promote teamwork, presentations, and public communication. This enables learners to effectively convey environmental knowledge and concepts to diverse stakeholders (Sarbassova et al., 2021).

8. Readiness for future labor market changes

Considering future labor market demands, the environmental sector is likely to undergo significant changes, particularly in renewable energy, waste and digital pollution management, and natural resource conservation amidst rapidly changing environmental conditions. For instance, Scotland shows a continuous upward trend in renewable energy sector employment (Sulich et al., 2020), reflecting expanding opportunities in environmental work. Curricula should be flexible and adaptable to evolving market demands.

These eight considerations demonstrate that developing environmental curricula to address rapid environmental changes is key to creating a workforce of knowledge and skills to confront complex future environmental issues. However, effective curriculum development requires collaboration among all sectors, including educational institutions, government, private sector, and communities, to create a learning ecosystem conducive to developing high-quality personnel.

In Connolly et al. (2022), a comprehensive framework for curriculum development is presented, clearly outlining expected learning outcomes for bachelor's, master's, and doctoral levels. At the bachelor's level, students are expected to possess broad foundational knowledge, demonstrate the application of key tools across diverse contexts, and exhibit professional autonomy in decision-making. For the master's level, students are required to display in-depth subject knowledge, develop and test hypotheses, design and solve

complex problems, and lead projects that reflect ethical considerations. Doctoral students must be capable of working at the cutting edge of the field, developing new methods, and understanding the societal impact of their problem-solving approaches.

This progression highlights the increasing depth and complexity of knowledge, skills, and competencies required at each educational level. Bachelor's programs emphasize foundational skills and knowledge, master's programs focus on advanced problem-solving and analysis, and doctoral programs center on knowledge creation and innovation. Developing modern curricula that address societal needs is essential for fostering sustainable economic, social, and environmental development in the long term.

Preparing students for future careers

The 21st- century world is facing rapid and uncertain changes, significantly altering the skills necessary for work and life. Consequently, the education system must adapt to prepare students with skills that align with current and future labor market and societal needs (Imam et al., 2023). Essential skills for students encompass various aspects, particularly creativity and innovation, which are crucial in an era of rapid technological change (Jamal et al., 2020). Additionally, the ability to self-learn is vital in an era where vast amounts of information are readily accessible (Karatas & Zeybek, 2020). Language skills and presentation abilities are also highly valued by employers in the globalized era (Heang et al., 2019).

Shamzzuzoha et al. (2022) distinguished between technical and generic skills in the context of green innovation, noting that both are crucial for promoting sustainable development. Technical skills are specialized abilities directly related to green innovation practices. For example, sustainable product design skills may include the ability to select environmentally friendly materials, design for product longevity, or facilitate easy recycling. Another example is carbon footprint calculation skills, which require scientific and mathematical knowledge to assess greenhouse gas emissions throughout a product or service's life cycle.

Conversely, generic skills are versatile abilities applicable across various situations and are equally important in promoting green innovation. For instance, ethical and sustainability thinking skills may be demonstrated through business decisions that consider long-term environmental and social impacts.

Additionally, collaboration skills are crucial generic skill, evident in the ability to coordinate between engineering, marketing, and production teams to develop environmentally friendly products that simultaneously meet market demands.

Therefore, teaching methods to develop these skills require changes in instructional and learning approaches. Naidoo (2021) suggests that educational institutions should adapt towards participatory teaching models, utilize technology as a learning tool, and promote analytical thinking and problem-solving. Integrating these skills into various courses, especially in social studies, can help learners better connect knowledge with real-life experiences (Oluwagbohunmi & Alonge, 2023).

Nevertheless, the integration of these skills into traditional curricula poses challenges, such as the gap between the skills employers' demand and those possessed by graduates (Almeida & Morais, 2023). Bridging this gap requires stronger collaboration among educational institutions, businesses, and policymakers to create curricula that respond more effectively to labor market needs (Crosta & Banda, 2022).

Cox and Montgomery (2019) advocate for more experiential learning, recommending longer and more meaningful internships that begin earlier in students' academic careers. However, they caution that cultural and contextual differences between countries must be considered, as skill priorities may differ based on economic and social circumstances (Crosta & Banda, 2022). As a result, curriculum development must be flexible and adaptable to local needs.

Furthermore, developing 21st century skills should not overlook the importance of instilling moral and social responsibility. Oluwagbohunmi and Alonge (2023) stress that education must cultivate socially and environmentally conscious individuals who use their skills for the greater good. Successfully integrating these skills will not only enhance graduates' career prospects but also foster the adaptability and innovation needed to tackle future challenges.

Opportunities and challenges for environmental schools in the transformation era

The establishment of environmental schools at the higher education level to create knowledge and environmental experts is a crucial concept in the context of today's world, which is facing severe and complex environmental crises. Based on the analysis of current

environmental situations, concepts in developing environmental curricula, and essential skills for future students, several opportunities and challenges have been identified (as shown in Fig. 3 and Table 1). This analysis leads to the determination of an effective management model for environmental schools in the future, as follows.
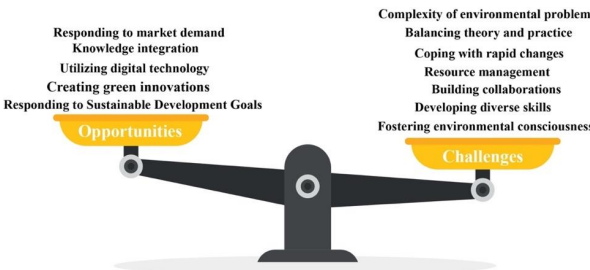

Fig. 3 Opportunities and Challenges of Environmental Schools

Table 1 Opportunities and Challenges of Environmental Schools

Opportunities	Challenges
1. **Responding to market demand:** Increasing demand for environmental experts due to complex and severe environmental problems.	1. **Complexity of environmental problems:** Developing curricula that cover complex and interconnected environmental issues across multiple dimensions is challenging.
2. **Knowledge integration:** Environmental schools can integrate knowledge from multiple disciplines, aligning with the holistic nature of environmental problems.	2. **Balancing theory and practice:** Need to design curricula that provide both theoretical knowledge and practical skills necessary for solving real-world problems.
3. **Utilizing digital technology:** Can apply digital technologies for pollution monitoring and control, enhancing environmental management efficiency.	3. **Coping with rapid changes:** Need to continuously update curricula to keep pace with rapidly changing environmental issues and technologies.
4. **Creating green innovations:** Schools can become centers for developing innovations to address environmental issues.	4. **Resource management:** Establishing environmental schools may require significant resources in terms of personnel, budget, and technology.
5. **Responding to sustainable development goals:** Environmental schools can contribute to achieving the United Nations' Sustainable Development Goals.	5. **Building collaborations:** Need to create collaborative networks with government agencies, private sector, and communities to link education and research with real-world problem-solving.
	6. **Developing diverse skills:** Need to develop academic skills, technological skills, critical thinking skills, and communication skills, which can be challenging in curriculum design.
	7. **Fostering environmental consciousness:** Beyond providing knowledge, need to instill good consciousness and attitudes towards environmental conservation in students.

Opportunities for establishing environmental schools

Given the rapid environmental changes occurring today, examining the opportunities for establishing environmental schools highlights key external factors that are beneficial for strategic planning. The opportunities discussed include:

1. Responding to Labor Market Demands: As environmental challenges become increasingly complex, there is a growing demand for environmental experts. Environmental schools have the opportunity to produce specialized professionals who meet this demand, thus benefiting the labor market and creating significant career opportunities for students.

2. Integrating Interdisciplinary Knowledge: Environmental problems span natural sciences, social sciences, and public policy, making interdisciplinary integration a crucial opportunity. Environmental schools can design curricula that combine knowledge from multiple fields, fostering a holistic perspective necessary for addressing complex environmental challenges. This integration not only enhances problem-solving but also establishes the institution's distinctive academic identity.

3. Utilizing Digital Technology: Leveraging digital technologies in environmental management offers significant opportunities for innovation and improving problem-solving efficiency. Environmental schools can incorporate technologies for pollution monitoring, natural resource management, and environmental data analysis. This integration enhances forecasting, decision-making, and the development of innovative solutions.

4. Creating Green Innovations: Environmental schools can become hubs for green innovation by fostering research, collaborating with industries, and supporting the development of sustainable technologies. This focus on green innovation can have both environmental and economic benefits, including the creation of green industries.

5. Aligning with the United Nations' Sustainable Development Goals (SDGs): Environmental schools can contribute to addressing global challenges by designing curricula and research aligned with the SDGs. This creates opportunities for international collaboration, enhances institutional credibility, and supports global efforts in natural resource conservation, climate adaptation, and sustainable production and consumption practices.

Challenges in establishing environmental schools

While the opportunities are significant, several challenges must be addressed in establishing effective environmental schools:

1. Addressing the Complexity of Environmental Issues: Environmental problems are multifaceted, crossing scientific, economic, social, and political boundaries. Developing curricula that effectively cover these interconnected dimensions and convey them to students poses a significant challenge.

2. Balancing Theory and Practice: A well-rounded environmental education requires both strong theoretical foundations and practical, real-world skills. Developing curricula that balance these aspects, while also establishing partnerships with external organizations for hands-on experience, requires substantial resources and effort.

3. Coping with Rapid Changes: Environmental issues and technologies are evolving rapidly. Keeping curricula relevant requires frequent updates. Ensuring faculty members remain knowledgeable and skilled in emerging trends presents an ongoing challenge.

4. Resource Management: Establishing and operating environmental schools requires significant financial, human, and technological resources. Efficient allocation of these resources, along with long-term financial sustainability, is a key operational challenge.

5. Building Cross-Sector Collaborations: Establishing strong partnerships with government agencies, private sectors, and communities is essential for linking education and research to real-world problem-solving. However, managing these collaborations and aligning external needs with the institution's academic mission is a demanding task.

6. Developing Diverse Skills: Solving environmental problems requires a range of skills, including critical thinking, technological expertise, and communication. Designing curricula that develop these diverse skills and implementing methods to assess them systematically is a complex challenge.

7. Fostering Environmental Consciousness: Beyond academic knowledge, environmental schools have the responsibility to instill ethical values and attitudes toward environmental conservation. Cultivating this consciousness requires sustained effort and is difficult to measure quantitatively.

Conclusion

This study analyzes the opportunities and challenges in establishing graduate-level environmental schools to address increasingly complex and severe environmental crises, particularly the impacts of global climate change. The research identifies five key opportunities: 1) responding to labor market demands, given the significant increase in demand for environmental experts 2) integrating interdisciplinary knowledge, which is essential for solving complex environmental problems 3) leveraging digital technologies in environmental management 4) fostering green innovations to address environmental issues and 5) supporting the United Nations' Sustainable Development Goals.

Concurrently, the study identifies seven primary challenges: 1) developing curricula that encompass complex environmental issues 2) balancing theory and practice; 3) adapting to rapid changes 4) managing necessary resources 5) building cross-sector partnerships 6) cultivating diverse skill sets in students and 7) fostering environmental consciousness.

The findings emphasize the importance of developing flexible curricula and integrating practical learning experiences. Additionally, they provide insights for policymakers and educational institutions in developing effective environmental schools for the future. The results underscore the potential of environmental schools to create positive societal and environmental impacts, particularly by developing human resources capable of navigating future social and environmental transitions.

In conclusion, this study not only provides in-depth information about establishing environmental schools but also opens doors to numerous opportunities for developing environmental education, research and innovation, and cross-sector collaboration to address the environmental challenges facing the world. Effectively applying the knowledge gained from this study will enhance society's ability to solve environmental problems and promote long-term sustainable development.

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